AN INTELLIGENT SHARED DATA NETWORK FOR AIS AND REMOTE CONTROLLED VTS VHF

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25 October 2001

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Abstract

IMO is gradually implementing the mandatory carriage of AIS from year 2002 and onwards. The dangerous coasts of Finland are particularly well suited to implement AIS on a large scale. It is going to enable the VTS community to monitor and exchange safety related data with the vessel traffic with an unprecedented accuracy and quality. This normally necessitates, however, building a network of AIS basestations along the coasts and inland waterways. The individual AIS coverages may overlap, the data transfer rates between the local nodes of the network may differ and network control and display facilities are required, but standards on how to implement AIS networks are still lacking. This document presents the Finnish solution. A method of determining the performance and coverage of an AIS station is shown.

A significant fringe benefit is that a remotely controlled VHF- base station network for VHF-use and even a GMDSS network may be included with only marginal incremental cost, as the infrastructure is almost identical. Thus significant cost savings may be achieved both regarding investment as well as running costs.

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The authors

Rolf Bäckström, who received a B.Sc. degree in radio engineering in 1968, has worked for the Finnish Maritime Administration, FMA, at the department of charts and fairways since 1968, presently as the head of the telematics section. The main tasks have been radionavigation and telematic systems, but also project management of the DECCA, DGPS, Port@Net, PilotNet, IBNet and AIS projects.

Mats Koivisto, is working as a Software Manager for the Finnish marine electronics company Navielektro Ky. The company has specialised in Marine and Surveillance electronics as well as AIS and VHF networks. Together with the Norwegian Company Navtek A/S, the company has built all the VTS systems in Finland, except one.

Lauri Kuokkanen, who received a M.Sc. degree from Oulu University in 19??, has been the owner and managing director of numerous companies, almost invariably dealing with innovative products based upon different aspects of RF filtering. He has received the renowned Nokia Technology Price in 1996.

Jouni Jokinen, who received an M.Sc. degree from the Helsinki University of Technology in 1998, is presently working for Digita Oy, who supplying the technical infrastructure for all the major broadcasting companies operating in Finland.

1. Background

IMO implements the mandatory carriage of the universal Automatic Identification System for ships from year 2002 and onwards in the SOLAS convention. FMA has been deeply involved right from the start and a network of AIS-base stations is planned along the coast of Finland, of which some stations already are implemented. Also the main inland waterways are planned to be covered. The network produces and distributes information on the whereabouts of all ships carrying AIS within the coverage area. Although the information provided is position and movement parameter information, it could be used for calculating automatically rather accurate ETAs or ETPs. Finland and Sweden have successfully tested interconnecting the AIS-systems of both countries.

The project to be described in this paper is just a part of a much larger scheme. It is also an expression for that the inland waterways should be considered as a part of the open waters of the sea. Ships from the sea frequently enter inland waterways and the systems the navigator encounters should be similar enough not to cause confusion.

When starting the project no experience on how to build an AIS network was available or how is the coverage determined and what kind of an availability was necessary. Although the theory of VHF propagation is quite well known and there is a lot of experience available, the nature of the transmission itself makes it difficult to estimate real performance. Hence it was necessary to start off with comprehensive tests to find the necessary baseline parameters to be used in the design phase.

2. The project plan

The overall master plan is simple. We want to track in all Finnish waters every single ship of any significance to maritime or environmental safety. This does not mean only radar coverage but a combined coverage of radar and AIS. Radar coverage is expensive to build particularly in areas like Finland, where there are plenty of good locations to build on but were energy and communication lines are difficult and expensive to acquire. Furthermore a satisfactory service level is difficult to maintain.

The VTS systems are already largely completed, but the AIS-network is still under construction. It consists of four parts, Gulf of Finland, Sea of Archipelago, the Gulf Bothnia and the Lake area Saimaa. The two first ones are already completed and the Lake Saimaa project is the project referred to in this paper. All the different areas are constructed in a star-like topology, centred around the VTS systems, enabling the VTS-systems to have maximum available update rates. These regional networks are then combined into one national AIS server, which already is in operation.

Since a number of years, we have an ongoing and well working relationship with the Finnish Coast Guard and the Defence Forces. We meet regularly, we actively discuss items of common interest were we could share the same infrastructure assets or if throwing our combined money in the same pot could get us more than if we would be acting alone. Among a large number of other things this has brought about the possibility to combine sensor networks and to utilise already existing large bandwidth communication lines at no or little cost. The plans for AIS and VTS networks are laid out in the annexed the maps at the of this paper. Unfortunately as the network is partly military so we cannot disclose how the network topology is built up.

3. The coverage measurements

General

During the testing phase of the AIS network in the Sea of Archipelago in 1998 it became evident that the nature of the AIS VDL (VHF Data Link) allows bi-directional data interchange between ship-shore with a reasonably good throughput. During the testing weather information to ships was distributed with fairly good results. The broadcast capability of AIS had been shown, but in order to fully utilise AIS as a tool between the ship and shore it was necessary to perform some tests to determine the actual throughput of the AIS VDL in a two-way communication scenario. In the end of the testing phase it was evident that there was a considerable loss of messages that used the maximum number of timeslots available and therefore some testing had to be done in order to establish the nature of the problem. A loss of messages containing the maximum number of timeslots would for instance have a negative impact on "VTS footprint" messages that are likely to be transmitted using the maximum amount of timeslots in order to preserve the bandwidth of the VDL.

The AIS VDL is a digital communications channel. Hence the throughput is often presented as a function of the BER (Bit Error Rate) and distance between the transceivers. As the AIS VDL is message based it would have been difficult to obtain the actual BER. Also, the value would have been of little use, as the smallest unit in the VDL is a message occupying one timeslot. The purpose of the field studies was to show the probability of successful message communication between two parties using different binary message lengths. This would prove to be valuable information for application developers that are going to utilise the AIS network for digital two-way communication.

The Test Scenario

A distributed testing environment had to be developed in order to be able to conduct the tests. The software of the shore based AIS network was modified to permit operation in echo mode or what in telecommunication terms is regarded as loop back mode.

The testing environment on board of the vessel consisted of a slightly modified Saab Transpondertech R3 transponder that had been modified to save the received RSSI (Received Signal Strength Indication) of each received position message.

In addition special test software was developed and installed on the vessel and at shore. The software generated test messages containing a bit pattern that was being continuously sent from ship to shore. The test data was transmitted repeatedly as one, two, three and four time-slot messages in order to establish the message error rate between the ship and shore. The shore based software recorded each received message and echoed the message back to the vessel using the same base-station. The vessel recorded each of the messages that had been transmitted and also recorded those messages that had been received by the shore side and successfully had been transmitted back to the vessel. The base station would transmit its own position periodically and the vessel noted the RSSI for each received position message.

The tests were conducted using a worst case scenario as the test environment was installed in a fairway service vessel with an antenna height of approximately 3m. The antenna on board of the ship was a typical 0 dB antenna. The height of the base-station antennas was between 30 and 70m above ground respectively. The base-station antennas were high gain 7 dB antennas that were directed towards the sea.

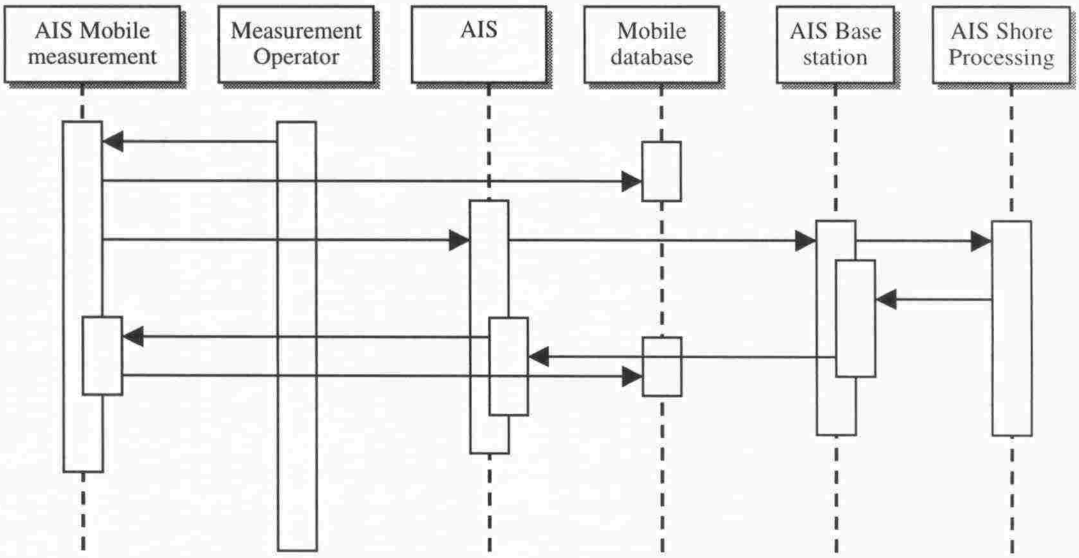
Although the coverage of some of the base stations were overlapping the tests were carried out as point-to-point communication between one of the base stations and the vessel at a time.

The field trials were conducted in various weather conditions during the summer of year 2000. The trial would start from the shore as close as possible to the base station being tested and proceed further away from the base station until no echoed messages could be received.

Picture: Block Diagram of the Test Scenario

Analysis of the tests results

The test results were recorded to a database that allowed post analysis of the data with considerable accuracy. The results were plotted on a chart as a function of RSSI or signal strength and distance, packet round trip success rate vs. distance.



Vessel Test Case (Unified Modeling Language) Test Sequence